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LOW-TEMPERATURE PLASMA

Study of a DC Gas Discharge with a Copper Cathode in a Water Flow

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Abstract—A dc gas discharge between copper electrodes in the current range of 5–20 A was studied experimentally. The discharge gap length was varied within 45–70 mm. The cathode was a 10-mm-diameter rod placed in the water flowing out from a dielectric tube. Three discharge configurations differing in the position of the cathode upper end with respect to the water surface were considered: (i) above water; (ii) flush with the water surface, and (iii) under water. The electric and optical characteristics of the discharge in the second configuration were studied in more detail. It is established that the discharge properties are similar to those of an electric arc. Considerable cathode erosion was observed in the third configuration. It is revealed that fine-dispersed copper grains form in the course of erosion.

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1. INTRODUCTION

In recent years, interest in gas discharges excited in the presence of aqueous media has increased considerably. Various kinds of gas discharges have been studied. Pulsed high-voltage discharges in water and on the water surface can be used as sources of UV radiation and chemically active substances [1–7]. An important practical application of such discharges is disinfection of water [8, 9]. Low-voltage underwater discharges are promising to destroy organic compounds and sterilize wastewater [10, 11]. Quite a lot of studies were devoted to the application of gas discharges to synthesize nanoparticles in water and aqueous solutions [12–15]. Tens of ways to implement this process were listed in reviews [16–18]. Plasma processes occurring at the contact of a gas discharge with water in the atmospheres of helium, argon, and other gases have been studied [19–21]. Under new conditions of the interaction of a gas discharge with water, its physicochemical properties manifest themselves most clearly.

This work is aimed at the experimental study of a dc gas discharge in air with a metal cathode in a water flow. In most previous experiments, the solid-state cathode was completely immersed in the water flow (see, e.g., [22–28]). Gas discharges in which the metal cathode comes out from the water flow or is close to such a position have received little study. This work is devoted to studying just this type of discharge.

2. EXPERIMENTAL

The scheme of the experiment is shown in Fig. 1. The discharge was ignited between a copper rod located in cathode unit *1* and water-cooled copper disk *2*, used as an anode. The experiments were carried out in the current range of 5–20 A.

The discharge was supplied from a three-phase two-half-period rectifier with an output voltage of 1200 V. The voltage pulsations were smoothened by means of capacitive–inductive filter *C*-*L*-*C*. The voltage was measured using voltmeter *V1* (an M2015 pointer instrument with a 0.2-class of accuracy) and additional resistance R_1. Resistance R_1 and voltmeter *V1* also served as a voltage divider when recording the electric signals using oscilloscope *3*. The current was measured with ammeter *A* (an M2016 multirange pointer instrument with a 0.2-class of accuracy) and recorded using oscilloscope *3*. The electric signal used to record the waveform of the discharge current was formed using shunt R_2 with a resistance of 0.50 Ω. The current was regulated with ballast resistor R_3 by varying its resistance by a step from 150 Ω to zero.

The electric field in the plasma column was measured by means of probe *4*, which was a 0.4-mm-diameter tungsten wire placed in a capillary quartz tube. The length of its open segment was 0.5 mm. The probe was introduced into the plasma column for a short time by using an electromagnet with a spring mechanism. Its spatial position was varied with a coor-